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METHOD OF MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICE

[Abstract]

PROBLEM TO BE SOLVED: To provide a method of manufacturing a liquid crystal device by which the device can be manufactured in a small number of processes in a short time as well as damages on the surface of glass substrates are decreased.

SOLUTION: A projected line 11 to surround the periphery of a pixel region is formed on the surface of at least one glass substrate 10 of a pair of glass substrates 10, 14 where at least one pixel region is to be formed, and a seal pattern 12 extending along the outside of the projected line 11 is formed on the glass substrate 10 or on the other glass substrate 14. Then a liquid crystal 13 is dropped into the space formed in the inside of the projected line 11, the glass substrates with the projected line and the

seal pattern inside are stacked at a specified distance determined by the height of the projected line, and then the seal pattern 12 is hardened to manufacture the liquid crystal device 15.

[Claims]

[Claim 1]

A method of producing a liquid crystal device, comprising:

forming a first projection on a surface of at least one glass substrate of a pair of glass substrates on which at least one pixel portion is formed so that the first projection surrounds the circumference of the pixel portion;

forming a seal pattern on a surface of one glass substrate or the other glass substrate so that the seal pattern extends along an outward side of the first projection;

injecting a liquid crystal in drops into a space surrounded by the first projection;

layering one pair of glass substrates so that the first projection and the seal pattern are interposed between the glass substrates and the substrates are spaced apart from each other at an interval corresponding to a height of the first projection, and attaching the substrates; and

curing the seal pattern to achieve sealing.

[Claim 2]

The method as set forth in claim 1, wherein the attachment of the substrates is conducted at atmospheric pressure.

[Claim 3]

The method as set forth in claim 2, wherein the attachment of the substrates is conducted at a reduced pressure.

[Claim 4]

The method as set forth in any one of claims 1 to 3, wherein a volume of the liquid crystal injected in drops is identical to that of the space surrounded by the first projection in the injection of the liquid crystal.

[Claim 5]

The method as set forth in any one of claims 1 to 3, wherein a volume of the liquid crystal injected in drops is slightly larger than that of the space surrounded by the first projection in the injection of the liquid crystal.

[Claim 6]

The method as set forth in any one of claims 1 to 5, further comprising forming a second projection around the outward side of the first projection so that the second projection is spaced apart from the first projection at an interval corresponding to a width of the seal pattern after the formation of the first projection and before the formation of the seal pattern.

[Claim 7]

The method as set forth in claim 6, wherein the second projection is formed on one glass substrate.

[Claim 8]

The method as set forth in any one of claims 1 to 7, wherein a sealing agent constituting the seal pattern is a UV-curable resin, and the curing of the seal pattern is conducted by radiation of ultraviolet rays during the sealing.

[Claim 9]

The method as set forth in any one of claims 1 to 7, wherein a sealing agent constituting the seal pattern is a thermosetting material, and the curing of the seal pattern is conducted by heat treatment during the sealing.

[Claim 10]

The method as set forth in any one of claims 1 to 9, further comprising cutting one pair of glass substrates at parts outward from the seal pattern or the second projection thereof to separate pixel portions therefrom after the sealing is conducted.

[Claim 11]

The method as set forth in any one of claims 1 to 10, wherein a liquid crystal cell which is formed by a first seal pattern has a diagonal length of 1 cm or less.

[Title of the invention]

METHOD OF MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICE

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates, in general, to a method of producing a liquid crystal device and, more particularly, to a method of producing a small liquid crystal device.

[Description of the Prior Art]

A conventional liquid crystal device is produced through a method shown in FIGS. 7 to 12 R>2. First, two glass substrates 101, 131 are prepared, and a gap control agent 101a (hereinafter, referred to as "GC agent") having a predetermined particle diameter is applied on the first glass substrate 101 using, for example a dispenser (D), as shown in FIG. 7a. Furthermore, at least one pixel electrode 103 is formed on a pixel portion (it is called a display portion or a light control portion) which is indicated by a dotted line of the glass substrate 101.

With respect to this, as shown in FIG. 7b, a common electrode 133 is formed on the second glass substrate 131 so as to correspond to the

pixel portion of the first glass substrate 101, and a sealing agent, to which the GC agent 135a having a predetermined particle diameter is added, is applied so as to surround a circumference of the common electrode 133 to form a seal pattern 135. The seal pattern 135 has an opening 135b acting as a liquid crystal inlet.

Additionally, as shown in FIG. 8a, the second glass substrate 131 is layered on the first glass substrate 101 so that the pixel electrode 103 corresponds in position to the common electrode 133, and, as shown in FIG. 8b, the first glass substrate 101 and the second glass substrate 131 are pressed using, for example, a press (P), so as to approach each other.

Subsequently, the pressed first and second glass substrates 101, 131 are heat treated using, for example, a heater (HT), and the seal pattern 135 is cured so as to fix the first and second glass substrates 101, 131 to each other. An empty cell (EC) is formed between the first glass substrate 101 and the second glass substrate 131 by the seal pattern 135 so as to correspond to the pixel portion. Furthermore, the sealing agent is made of thermosetting material and cured by heat treatment. However, a sealing agent containing a UV-curable resin may

be used, and, in this case, UV rays are radiated thereonto instead of conducting heat treatment so as to cure the sealing agent.

In practice, as shown in FIG. 9a, a plurality of empty cells (EC) is formed between the first glass substrate 101 and the second glass substrate 131, and scribe lines (SL) are formed along boundaries between the empty cells (EC) using, for example a diamond cutter (D), on surfaces of the first glass substrate 101 and the second glass substrate 131. Of the scribe lines (SL), the transverse scribe lines (SL) in FIG. 9a are formed parallel to the liquid crystal inlets 135b formed in the empty cells (EC). As well, the first glass substrate 101 and the second glass substrate 131 are cut along the scribe lines (SL) to separate the empty cells (EC) from each other as shown in FIG. 9b.

Subsequently, as shown in FIG. 10, a plurality of empty cells (EC) is fixed into an injection jig 150 so that the liquid crystal inlets 135b are located on the same plane, and put with a liquid crystal tank 155 containing liquid crystals (E) into a vacuum chamber (VC) as shown in FIG. 11a. The vacuum chamber (VC) is then vacuumized. When a predetermined vacuum has been established in the vacuum chamber (VC), as shown in FIG. 11b, the injection jig 150 moves so that the liquid

crystal inlets 135b of the empty cells (EC) are immersed in the liquid crystals (E) in the liquid crystal tank 155. Subsequently, pressure inside the vacuum chamber (VC) is set to atmospheric pressure so that the liquid crystals (E) are charged in the empty cells (EC), thereby liquid crystal cells (LC) are created.

As shown in FIG. 12a, the liquid crystal cells (LC) are fixed into a press jig 161 so that the liquid crystal inlets 135b partially protrude from the press jig. The liquid crystal cells (LC) are pressed using a predetermined pressure for a predetermined time, and the liquid crystals (EA) which ooze through the liquid crystal inlets 135b are scrubbed off. As shown in FIG. 12b, for example, an end sealing agent (ES) is applied so as to seal the liquid crystal inlets 135b, and is cured by the radiation of ultraviolet rays or heat treatment. Thereby, the liquid crystal cell (LC), that is, a liquid crystal device, is created.

[Problems to be Solved by the Invention]

The method of producing the above-mentioned liquid crystal device has the following problems.

First, it is necessary to cut sides of first and second glass

substrates 101 and 131, at which liquid crystal inlets 135b are formed, so that the sides are smooth, and it is impossible to form an extraction electrode on a portion of the glass substrates, which is positioned around the liquid crystal inlets. Accordingly, the degree of freedom is reduced in the design of the liquid crystal device.

Second, since very many processes (they are difficult to automatize) are necessary and the production process is complicated, a production cost and a production time increase. Particularly, in the case in which a small liquid crystal cell is produced, it takes a long time to fix an empty cell (EC) or a liquid crystal cell (LC) into an injection jig or a press jig. Additionally, when the empty cells (EC) are undesirably fixed into the injection jig (when the liquid crystal inlets 135b are not located on the same plane), a portion of the liquid crystal inlets 135b is not immersed in a liquid crystal (E), thus poor liquid crystal injection is achieved. This process is difficult to automatize, and, if it is manually conducted, it requires skill.

Third, since a fixing process, using an injection jig or a press jig, or a pressing process, is frequently required, surfaces of the empty cells (EC) or the liquid crystal cells (LC) are readily damaged. Particularly,

many scraps (impurities generated during a cutting process) of the glass substrate become attached to the surface of the glass substrate after scribe lines (SL) are formed on the glass substrate or after the glass substrate is cut using a breaking process, thus the surface of the glass substrate is readily damaged during subsequent processes. In connection with this, a washing process may be additionally conducted to remove glass powder, but is problematic in that the number of processes increases and it is difficult to completely remove the glass powder using the washing process.

Fourth, the alignment of liquid crystals is undesirable around a seal pattern 135 or an end seal part. The undesirable alignment of the liquid crystals is not problematic in a large liquid crystal device, but, in a small liquid crystal device, since the distance between the seal pattern or the end seal part and a display part is relatively short, resistances of the liquid crystals vary depending on the undesirable alignment of the liquid crystals, resulting in a poor display.

The present invention has been made keeping in mind the above-mentioned description, and an object of the present invention is to provide a method of producing a small liquid crystal device in a short

time employing a small number of processes so that damage to a surface of a glass substrate is reduced.

[Means for Solving the Problem]

In order to accomplish the above object, as disclosed in claim 1, the present invention provides a method of producing a liquid crystal device. The method comprises forming a first projection on a surface of at least one glass substrate of a pair of glass substrates on which at least one pixel portion is formed so that the first projection surrounds the circumference of the pixel portion, forming a seal pattern on a surface of one glass substrate or the other glass substrate so that the seal pattern extends along an outward side of the first projection, injecting a liquid crystal in drops into a space surrounded by the first projection, layering one pair of glass substrates so that the first projection and the seal pattern are interposed between the glass substrates and the substrates are spaced apart from each other at an interval corresponding to a height of the first projection, attaching the substrates, and curing the seal pattern to achieve sealing.

According to claim 1, since the injection of the liquid crystal into

the space (liquid crystal cell) formed by the first projection is conducted before the separation of the liquid crystal cells, it is unnecessary to align openings of liquid crystal inlets of the liquid crystal cells using an injection jig. Accordingly, the number of processes may be small, production cost and time are reduced, and the present invention is very useful to produce a small liquid crystal cell because the liquid crystal cells are easily handled. Furthermore, it is unnecessary to form the liquid crystal inlets at the liquid crystal cells, thus external electrodes can be formed around the liquid crystal cells. Hence, the degree of freedom of design is increased. Since a pressing process is conducted using gas pressure or liquid pressure in a non-contact press manner, it is possible to reduce damage to the surface of the glass substrate.

The sealing process is conducted by curing the seal pattern, thus it is unnecessary to fix the liquid crystal cells into a press jig unlike a conventional method. Since it is unnecessary to force the liquid crystal to flow, the time required to conduct the sealing process is significantly reduced and the production time of the liquid crystal device is reduced. Thereby, productivity of the liquid crystal device is improved.

Since the liquid crystal is contained in the sealed space formed by

the first projection, the liquid crystal does not come into direct contact with the seal pattern. Accordingly, undesirable alignment or changes in resistance of the liquid crystals depending on the seal pattern do not occur, and it is possible to assure a desirable display. Therefore, it is possible to bring the projection and the seal pattern maximally close to boundaries between the pixel portions, thus it is unnecessary to assure a sealing margin. Hence, the size of the liquid crystal cell with respect to the pixel portion can be maximally reduced, and it is possible to reduce the amount of liquid crystal injected into the liquid crystal cell.

Furthermore, unlike the conventional method, it is unnecessary to conduct a processes in which the liquid crystal oozing from the liquid crystal cell is recovered and the recovered liquid crystal is reused, thus contamination due to repetition of injection of the liquid crystal can be prevented. Hence, it is possible to inject clean liquid crystal. It is necessary for the seal pattern to have sealing performance, but it is unnecessary to force the seal pattern to have rigidity, thus it is possible to reduce the width of the seal pattern to be as thin as possible. Thereby, it is possible to still further downsize the liquid crystal cell.

The invention of claim 2 is characterized in that, in the method of

claim 1, the attachment of the substrates is conducted at atmospheric pressure. According to the construction of claim 2, when a pair of glass substrates is attached to each other, a vacuum chamber is unnecessary, thus the attachment of the glass substrates is easily achieved for a short time at low cost.

The invention of claim 3 is characterized in that, in the method of claim 1, the attachment of the substrates is conducted at reduced pressure. According to the construction of claim 3, when a pair of glass substrates is attached to each other, bubbles are incorporated into the liquid crystal cell, which is caused by the flow of air between the substrates.

The invention of claim 4 is characterized in that, in the method of any one of claims 1 to 3, the volume of the liquid crystal injected in drops is identical to that of the space surrounded by the first projection in the injection of the liquid crystal. According to the construction of claim 4, since the volume of the liquid crystal injected in drops into the space is identical to that of the space surrounded by the first projection in the injection of the liquid crystal, it is possible to pack the liquid crystal therein so that the liquid crystal does not flow out of the space and pores

are not formed in the space during the subsequent attachment process.

The invention of claim 5 is characterized in that, in the method of any one of claims 1 to 3, the volume of the liquid crystal injected in drops is slightly larger than that of the space surrounded by the first projection in the injection of the liquid crystal. According to the construction of claim 5, since the volume of liquid crystal injected in drops into the space is slightly larger than that of the space surrounded by the first projection in the injection of the liquid crystal, the liquid crystal oozes from the space and flows over the first projection and between the first projection and the seal pattern, thus pushing the seal pattern outward during the subsequent attachment process. However, the liquid crystal is held by the seal pattern and does not flow over the seal pattern.

The invention of claim 6 is characterized in that the method of any one of claims 1 to 5 further comprises forming a second projection around the outward side of the first projection so that the second projection is spaced apart from the first projection at an interval corresponding to the width of the seal pattern after the formation of the first projection and before the formation of the seal pattern. According to the construction of claim 6, during the attachment process, when the

liquid crystal which oozes from the space formed by the first projection pushes the seal pattern, the second projection supports the seal pattern so as to prevent outward deformation of the seal pattern, thereby the width of the seal pattern is maintained at a predetermined value.

The invention of claim 7 is characterized in that, in the method of claim 6, the second projection is formed on one glass substrate. According to the construction of claim 7, during the attachment process, the seal pattern is interposed between the first projection and the second projection, thus the seal pattern protrudes outward from the second projection when the liquid crystal is pushed outward so as to push the seal pattern. In this case, the width of the seal pattern is maintained at a predetermined value by the second projection, and the second projection closely adheres through the seal pattern to the surface of the glass substrate.

The invention of claim 8 is characterized in that, in the method of any one of claims 1 to 7, a sealing agent constituting the seal pattern is a UV-curable resin, and the curing of the seal pattern is conducted by the radiation of ultraviolet rays during the sealing. According to the construction of claim 8, the ultraviolet rays are wholly radiated onto the

resulting structure to cure the sealing agent, thereby the liquid crystal cell is sealed by the cured seal pattern. Hence, the sealing is easily achieved in a short time in comparison with a sealing process using an end sealing agent through a conventional pressing process.

The invention of claim 9 is characterized in that, in the method of any one of claims 1 to 7, the sealing agent constituting the seal pattern is a thermosetting material, and the curing of the seal pattern is conducted by heat treatment during the sealing. According to the construction of claim 9, the entire resulting structure is subjected to the heat treatment to cure the sealing agent, thereby the liquid crystal cell is sealed by the cured seal pattern. Hence, the sealing is easily achieved in a short time in comparison with the sealing process using the end sealing agent through the conventional pressing process.

The invention of claim 10 is characterized in that, the method of any one of claims 1 to 9 further comprises cutting one pair of glass substrates at parts outward from the seal pattern or the second projection thereof to separate pixel portions therefrom after the sealing is conducted. According to the construction of claim 10, in the separation process, the liquid crystal cells are separated from each other to produce a plurality of

liquid crystal devices, thereby productivity is improved.

The invention of claim 11 is characterized in that, in the method of any one of claims 1 to 10, the liquid crystal cell which is formed by a first seal pattern has a diagonal length of 1 cm or less. According to the construction of claim 11, the liquid crystal device is produced using the small liquid crystal cell, and the liquid crystal cell is formed by the projection surrounding the pixel portion. The interval (hereinafter, referred to as "cell thickness") between the glass substrates is maintained by the height of the projection. Since it is possible to produce a small liquid crystal cell, uniform cell thickness throughout the pixel portion can be obtained.

As described above, the method of the present invention comprises forming a projection at a part inside a seal pattern forming a liquid crystal cell, applying a liquid crystal in drops into a space formed by the projection, attaching a pair of glass substrates to each other, and curing the seal pattern to seal the space. Thereby, the liquid crystal is simultaneously injected into the liquid crystal cells instead of injecting the liquid crystal into the separated liquid crystal cells after the liquid crystal cells are separated, the glass substrates are attached to each other, and

the sealing is achieved by curing the seal pattern. Accordingly, it is possible to easily produce a liquid crystal device in a short time in comparison with a conventional sealing process using an end sealing agent after the surplus liquid crystal is discharged using a press jig. Since the liquid crystal cell is formed by the projection, the liquid crystal in the liquid crystal cell does not come into contact with the seal pattern. Hence, the liquid crystal does not come into contact with the seal pattern, and undesirable alignment or a change in resistance of the liquid crystal does not occur. Thereby, desirable displaying is obtained and it is unnecessary to assure a sealing margin around a pixel portion, thus it is possible to produce a small liquid crystal cell.

[Embodiment of the Invention]

Hereinafter, a description will be given of a method of producing a liquid crystal device according to the present invention. In the method of producing the liquid crystal device according to the present invention, as shown in a flow chart of FIG. 1, the liquid crystal device is produced through the following procedure.

First, the following process is conducted as a preliminary step.

In step 1, a projection which has a height corresponding to a liquid crystal cell is formed on a surface of any one glass substrate of a pair of glass substrates, so as to surround a circumference of a pixel portion constituting a display part or a light control part. Simultaneously, in step 2, a sealing agent is applied on a surface of the one glass substrate or the other glass substrate so as to extend along an outward part of the projection, resulting in formation of a seal pattern. The projection is made of solid material. As well, the seal pattern completely surrounds the corresponding pixel portion and projection, and does not have a liquid crystal inlet. Additionally, a GC agent may or may not be dispersed on the glass substrates.

Subsequently, the following liquid crystal injection process is conducted. In step 3, in a space (liquid crystal cell) formed by the projection, a liquid crystal having a volume that is identical to or slightly larger than the space is added in drops. Thereby, the liquid crystal is charged in the liquid crystal cell formed in the pixel portion.

Next, the following attachment process is carried out. In step 4, one substrate is layered on the top of the other substrate. In this case, the glass substrates are spaced apart from each other by the projection.

If the liquid crystal cell has a diagonal length of 1 cm or less, it is possible to obtain uniform cell thickness. At this stage, the attachment of the substrates is conducted under atmospheric pressure or reduced pressure.

Next, the following sealing process is conducted. In step 5, after the liquid crystal cells are pressed during a pressing process, the seal pattern is cured. The sealing agent constituting the seal pattern is made of, for example, a UV-curable resin or thermosetting material, and is cured by the radiation of ultraviolet rays or heat treatment. Accordingly, if the sealing agent is made of the UV-curable resin, the seal pattern is cured by the radiation of ultraviolet rays, and, if the sealing agent is made of the thermosetting material, the seal pattern is cured by the heat treatment.

Finally, the following separation process is conducted. In step 6, a pair of glass substrates is cut by scribing and breaking at parts outside the seal patterns thereof, thus the liquid crystal cells are separated from each other in accordance with the pixel portions. Thereby, a liquid crystal device having one pixel portion is created.

As described above, according to the method of producing the

liquid crystal device of the present invention, since the seal pattern does not have a liquid crystal inlet, it is unnecessary to conduct a press end sealing process including extrusion of the liquid crystal, unlike a conventional method. Therefore, the production time of the liquid crystal device is reduced, and it is possible to form extraction electrodes at all sides of the liquid crystal cell, thus the degree of freedom is increased in designing the liquid crystal device. Hence, the liquid crystals do not come into contact with the seal pattern due to the projection, preventing undesirable alignment of the liquid crystals.

FIGS. 2 and 3 illustrate a method of producing a liquid crystal device according to the first embodiment of the present invention.

In a preliminary step, as shown in FIG. 2a, a glass substrate 10 which has, for example, a length and a width of 150 mm and a thickness of 0.5 mm, and in which a plurality of pixel pattern electrodes made of ITO films is formed in pixel portions is prepared, and projections 11 having the same height as a desired cell thickness are formed on a surface of the glass substrate 10 so that each projection 11 completely surrounds the circumference of the pixel portion. In FIGS. 2a to 2c, only one pixel portion is shown in order to make the drawings brief and

clear. However, in practice, a plurality of pixel portions is longitudinally and transversely formed on the glass substrate 10.

In connection with this, a plurality of projections 11 is longitudinally and transversely formed in, for example, a square having a length and a width of 8 mm, so that each projection surrounds the pixel pattern electrode (pixel portion) made of the ITO film on the glass substrate 10. The projections 11 are made of solid material, for example Optimo NN777 manufactured by JSR Inc., and each has a height of 5 μm and a width of 10 μm. Furthermore, the projections 11 may be made of solid material, for example, material which is produced by curing the sealing agent constituting the seal pattern 12 as described later, or another solid material, such as a Mylar film.

Next, as shown in FIG. 2b, a seal pattern 12 is formed on the surface of the glass substrate 10 using, for example, a dispenser (D), so as to extend along an outward side of the projection 11. The seal pattern 12 is formed so as to come into contact with the outward side of the projection 11, and completely surrounds the projection 11 without a liquid crystal inlet as shown in FIG. 2c. The sealing agent constituting the seal pattern 12 is a UV-curable material, for example, XNR5614

manufactured by Nagasechiba Corp., and is applied on the glass substrate 10 so that the seal pattern 12 has a width of 0.1 – 0.3 mm after the substrates are attached.

Next, as shown in FIG. 2b, in a liquid crystal injection process, in a space (liquid crystal cell) formed by the projection 11 on the surface of the glass substrate 10, a liquid crystal 13 having a volume that is identical to or slightly larger than the space is added thereinto in drops. Since the liquid crystal cell is small, it is important to very precisely control the volume of liquid crystal 13 to produce the liquid crystal cell having a uniform thickness. Therefore, it is preferable that the application of the liquid crystal be conducted using an inkjet process or a bubble jet (registered trademark) process. Alternatively, another process, such as a dispensing process, may be employed as long as it can very precisely control the volume of liquid crystal. Since it is difficult to set the volume of liquid crystal to be completely identical to that of the liquid crystal cell, the volume of liquid crystal is set to be slightly larger than that of the liquid crystal cell to prevent bubbles from occurring in the liquid crystal cell.

Next, in the attachment process, the glass substrate 10, on which

the projection 11 and the seal pattern 12 are formed and the liquid crystal 13 is applied in drops, is put, together with a glass substrate (opposite substrate) 14, into a vacuum chamber 20 as shown in FIG. 2b. While pressure in the vacuum chamber 20 is reduced almost to vacuum, one substrate is layered on the top of the other substrate. Due to the reduced pressure, bubbles are prevented from remaining in the liquid crystal cell. Additionally, it is possible to use a vacuum pack instead of the vacuum chamber 20.

In connection with this, the substrates 10, 14 are disposed so that they are completely parallel to each other. Furthermore, they are layered so that the opposite substrate 14 comes into contact with the most largely swollen portion of the liquid crystal 13 while the liquid crystal 13 surrounded by the projection 11 slightly swells due to a surface tension. If the opposite substrate 14 comes into contact with the surface of the liquid crystal 13 at a portion of the liquid crystal cell, the bubbles have a difficulty in remaining therein, thus the substrates 10, 14 may be attached to each other at atmospheric pressure. Even if some bubbles remain in the liquid crystal cell, deterioration of the display due to the bubbles does not occur if the bubbles are not

positioned on the pixel portion, thus it is possible to attach the substrates to each other at atmospheric pressure.

Next, as shown in FIG. 3e, the glass substrate 10 and the opposite substrate 14 which are attached to each other are pressed during a pressing process, and preferably left for a while so as to sink the bubbles thereinto. Ultraviolet rays irradiate the resulting substrates. While the seal pattern 12 is cured, the glass substrate 10 and the opposite substrate 14 are attached and thus fixed to each other. When the substrates are attached at reduced pressure, the pressing process is achieved merely by increasing the pressure to atmospheric pressure. If a seal pattern (it is formed so as to surround a device, and an inside surrounded by the seal pattern is in a near vacuum state) is additionally formed on a girth of the substrate (a portion to be removed, which does not constitute the device), a pressing effect is improved.

In the pressing process, as shown in FIG. 3f, the liquid crystal 13 oozes from the liquid crystal cell through an interval between the projection 11 and an ITO electrode on the opposite substrate. At this stage, since the seal pattern 12 is not completely cured, the liquid crystal 13 pushes the seal pattern 12. The seal pattern 12 is deformed outward,

thereby absorbing overflowing surplus liquid crystal 13. If the volume of the liquid crystal 13 which is dropped into the liquid crystal cell is smaller than that of the liquid crystal cell, the bubbles remain in the liquid crystal cell, the liquid crystal cell becomes thin at the center thereof due to high viscosity of the liquid crystal, or the sealing agent is injected into the liquid crystal cell due to negative pressure. Accordingly, it is preferable that the volume of liquid crystal 13 be identical to or slightly larger than that of the liquid crystal cell as described above.

Even if the seal pattern 12 is deformed by the liquid crystal 13, it is sufficiently oxygen-tight and does not affect the alignment or electrical properties of the liquid crystal 13 surrounded by the projection 11. Accordingly, since the liquid crystal 13 which is surrounded by the liquid crystal cell 13 does not come into direct contact with the seal pattern 12, undesirable alignment or a change in resistance does not occur, thus it is possible to assure a desirable display. Furthermore, an annealing process may be conducted after the radiation of ultraviolet rays so as to improve the effect of the seal pattern 12 which is caused by the radiation of ultraviolet rays.

Finally, the liquid crystal cells which are formed by the seal patterns 12 are separated from each other. The glass substrate 10 and the opposite substrate are subjected to scribing and breaking processes along an outward side of the seal pattern 12, using, for example, a diamond cutter (C), so as to separate the liquid crystal cells from each other as shown in FIG. 3g, thereby liquid crystal devices 15 are created.

FIG. 4 illustrates a method of producing a liquid crystal device according to the second embodiment of the present invention. The method of producing the liquid crystal device shown in FIG. 4 is different from the methods shown in FIGS. 2 and 3 in that the seal pattern 12 is not formed on a surface of the glass substrate 10 but a seal pattern 16 is formed on the opposite substrate 14. Other production processes, with the exception of the above-mentioned difference, are conducted according to the methods of FIGS. 2 and 3. During the production of the liquid crystal device, in the pressing process, when the liquid crystal 13a oozes from the liquid crystal cell between the projection 11 and the opposite substrate 14, the oozing liquid crystal 13a flows between the seal pattern 16 and the opposite substrate 14, thus the attachment strength between the seal pattern 16 and the opposite substrate 14 is not

reduced.

FIG. 5 illustrates a method of producing a liquid crystal device according to the third embodiment of the present invention. The method of producing the liquid crystal device shown in FIG. 5a is different from the methods shown in FIGS. 2 and 3 in that the projection 11 is not formed only on a surface of the glass substrate 10 but projections 11a, 11b are formed on the glass substrate 10 and the opposite substrate 14. Other production processes except the above-mentioned difference are conducted according to the methods of FIGS. 2 R>2 and 3. During the production of the liquid crystal device, in the pressing process, the liquid crystal 13a oozes from the liquid crystal cell between the projections 11a, 11b, and uniformly oozes from all sides of the liquid crystal cell while it is not affected by the shape of the electrode pattern formed on the surface of the opposite substrate 14. Thus, it is possible to reliably assure desirable attachment strength between the seal pattern 12 and the glass and opposite substrates 10, 14.

FIG. 6 illustrates a method of producing a liquid crystal device according to the fourth embodiment of the present invention. The method of producing the liquid crystal device shown in FIG. 6 is different

from the methods shown in FIGS. 2 and 3 in that a second projection 17 is formed so as to surround the projection 11 formed on the surface of the glass substrate 10 while it is spaced apart from the projection 11 by an interval corresponding to a width of the seal pattern 12. Other production processes, with the exception of the above-mentioned difference, are conducted according to the methods of FIGS. 2 and 3. During the production of the liquid crystal device, in the pressing process, when the liquid crystal 13a oozes from the liquid crystal cell between the projection 11 and the opposite substrate 14, since a lateral movement of the seal pattern 12 is restricted by the second projection 17, outward deformation of the seal pattern 12 due to the liquid crystal 13a does not occur. Accordingly, the width of the seal pattern 12 can be set to be narrow, thereby it is possible to produce a small liquid crystal cell.

FIG. 7 illustrates a method of producing a liquid crystal device according to the fifth embodiment of the present invention. The method of producing the liquid crystal device shown in FIG. 7a is different from the method shown in FIG. 6 in that the second projection 17 is not formed on the surface of the glass substrate 10 but a second projection 17a is formed on the opposite substrate 14. Other production

processes, with the exception of the above-mentioned difference, are conducted according to the method of FIG. 6. During the production of the liquid crystal device, in the pressing process, when the liquid crystal 13a oozes from the liquid crystal cell between the projection 11 and the opposite substrate 14, since a lateral movement of the seal pattern 12 is restricted by the second projection 17a as shown in FIG. 7b, the oozing liquid crystal 13a cannot deform the seal pattern 12 outward. A portion of the seal pattern 12 protrudes outward between the second projection 17a and the glass substrate 10 due to the oozing liquid crystal 13a, thus the attachment strength between the seal pattern 12, the glass substrate 10 and the opposite substrate 14 is not decreased.

In the above-mentioned embodiments, the projections 11, 11a, and 11b, the second projections 17 and 17a, and the seal patterns 12 and 16 are substantially rectangular. However, they are not limited to that shape, but may have other shapes, if necessary. Furthermore, in the above-mentioned embodiments, a press jig or a press is typically employed, or a structure in which a cushion member, such as urethane rubber, is attached to the press is used in the pressing process. However, the pressing process is not limited to the above process, but a

process in which pressure is applied using pressure of gas, such as air or nitrogen, or pressure of liquid, such as water, in a non-contact manner, or another process in which pressure is applied using a vacuum pack may also be employed.

In the above-mentioned embodiments, the glass substrate 10 and the opposite substrate 14 are subjected to scribing and breaking processes using, for example, a diamond cutter (C), to separate the liquid crystal devices 15. However, the separation is not limited to the above process, but the glass substrate and the opposite substrate may be cut using a diamond cutter to which ultrasonic vibration is applied employing a piezo, or using a high power laser cutter. In this case, during the cutting process, glass powder is not generated and it is unnecessary to conduct the breaking process, thus it is possible to produce a liquid crystal device with reduced incidence of damage.

Additionally, in the above-mentioned embodiments, the sealing agent constituting the seal patterns 12, 16 is made of a UV-curable resin. However, it is not limited to the resin but may be made of thermosetting material. In this case, the sealing agent is cured through heat treatment using an oven or a hot plate as well as a heater. In the above-

mentioned embodiments, a GC agent is not contained in the liquid crystal cell, but the GC agent may be dispersed on, for example, the pixel portions of the glass substrate 10 or the opposite substrate 14.

The liquid crystal device which is produced through the method of producing the liquid crystal device according to the present invention is applied to goods having a liquid crystal display, particularly a small liquid crystal display, a space modulation device of a light source for recording on an instant film · photographic paper, a light pickup device for CD/DVD, an iris · shutter of a camera, a liquid crystal light shutter for a laser printer, a liquid crystal lens, a liquid crystal prism, a liquid crystal light head, or a liquid crystal sensor.

[Effect of the Invention]

As described above, a method of producing a liquid crystal device according to the present invention has the following advantages. 1) Since the number of processes is reduced, it is possible to reduce production cost and production time. Particularly, it is very useful as a method for producing a small liquid crystal cell having a small area of display part (or light control part).

2) Since a conventional press end sealing process is unnecessary, the degree of freedom is increased in designing an external electrode. Accordingly, it is possible to provide an extraction electrode around, for example, a liquid crystal cell.

3) In a separation process during which glass powder, considered the main cause of scratches, is generated, scribing and breaking processes correspond to a final process of the method of producing the liquid crystal device, thus it is possible to minimize damage to the surface of a glass substrate of the liquid crystal cell.

4) All pressing processes can be conducted through a non-contact pressing process using gas pressure or liquid pressure. Accordingly, it is possible to further suppress damage to the surface of the glass substrate of the liquid crystal cell.

5) Since the sealing of a liquid crystal inlet is conducted by curing curable liquid 22 employing the radiation of ultraviolet rays or heat treatment, it is unnecessary to extrude the liquid crystal or provide a press jig, unlike a conventional method, thus the production time of the liquid crystal device is reduced.

6) Since the liquid crystal 13 in the liquid crystal cell does not come

into direct contact with the seal patterns 12, 16, undesirable alignment or a change in electrical properties, such as resistance, of the liquid crystals 13 does not occur. Hence, it is unnecessary to assure sealing margins around the pixel portions, unlike the conventional method, it is possible to bring the projection 11 and the seal patterns 12, 16 maximally close to boundaries between the pixel portions, or it is possible to reduce the size of the liquid crystal cell and the liquid crystal device 15. Since the size of the liquid crystal cell is reduced, the volume of liquid crystal 13 which is dropped into the liquid crystal cell is reduced, thus the amount of liquid crystal used is reduced. Furthermore, unlike the conventional method, it is unnecessary to conduct processes in which the injected liquid crystal is discharged during the pressing process and recovered, and the recovered liquid crystal is reused, thus contamination due to the repeated injection of liquid crystal does not occur.

7) Second projections 17, 17a are formed to define the width of the seal pattern 12.

Accordingly, since the width of the seal pattern 12 can be reduced to be as thin as possible, the entire liquid crystal cell can be smaller.

Thereby, in the present invention, it is possible to provide a method

of producing a small excellent liquid crystal device through a small number of processes in a short time so that damage to the surface of a glass substrate is reduced.

[Description of Drawings]

FIG. 1 is a flow chart illustrating a method of producing a liquid crystal device according to the present invention.

FIGS. 2a to 2d stepwisely illustrate a method of producing a liquid crystal device according to the first embodiment of the present invention (the first half of the procedure).

FIGS. 3e to 3g stepwisely illustrate the method of producing the liquid crystal device according to the first embodiment of the present invention (the last half of the procedure).

FIG. 4 schematically illustrates substrates before they are attached to each other in a method of producing a liquid crystal device according to the second embodiment of the present invention.

FIGS. 5a and 5b schematically illustrate substrates before they are attached (FIG. 5a) and after they are attached (FIG. 5b) in a method of producing a liquid crystal device according to the third embodiment of

the present invention.

FIG. 6 is schematically illustrates substrates before they are attached to each other in a method of producing a liquid crystal device according to the fourth embodiment of the present invention.

FIGS. 7a and 7b schematically illustrate substrates before they are attached (FIG. 7a) and after they are attached (FIG. 7b) in a method of producing a liquid crystal device according to the fifth embodiment of the present invention.

FIGS. 8a and 8b illustrate a process of producing a conventional liquid crystal display device, in which FIG. 8a shows the application of a spacer agent on a first substrate and FIG. 8b shows the application of a sealing agent on a second substrate.

FIGS. 9a and 9b illustrate a subsequent process of FIG. 7 in the process of producing the conventional liquid crystal display device, in which FIG. 9a shows the layering of substrates and FIG. 9b shows the pressing of the layered substrates.

FIGS. 10a and 10b illustrate a subsequent process of FIG. 8 in the process of producing the conventional liquid crystal display device.

FIG. 11 illustrates a subsequent process of FIG. 9 in the process of

producing the conventional liquid crystal display device.

FIGS. 12a and 12b illustrate a subsequent process of FIG. 10 in the process of producing the conventional liquid crystal display device, in which FIG. 12a shows the liquid crystal device contained in a vacuum chamber and FIG. 12b shows the feeding of a liquid crystal into a liquid crystal cell.

FIGS. 13a and 13b illustrate a subsequent process of FIG. 11 in the process of producing the conventional liquid crystal display device, in which FIG. 13a shows the removal of the oozing liquid crystal and FIG. 13b shows the sealing of an inlet of the liquid crystal device.

[Description of Reference Numerals]

10: glass substrate, 11, 11a, 11b: projection, 12, 16: seal pattern, 13: liquid crystal, 14: opposite substrate, 15: liquid crystal device, 16: seal pattern, 17, 17a: second projection, 20 vacuum chamber